Preface for COST860 SUSVAR discussion documents

Østergård, Hanne

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Seven discussion documents were made during the SUSVAR Visions workshop 'Sustainable cereal production beyond 2020: Visions from the SUSVAR[1] network', Karrebæksminde, Denmark, 14-16 April 2008. At the workshop, one discussion documents was written for each of the topics mentioned below. In total 55 persons from 21 European countries participated in the process. The participants came from different disciplines: genetics, plant breeding, genetic resources, agronomy, plant pathology, soil science, biometry and system analysis, all specialised in the area of cereal production.

The approach taken at the workshop was to focus on envisioning the future of sustainable agriculture, especially cereal production. This was done by scientific creative thinking on the basis of possibilities in breeding, management and seed production and not on the basis of traditional problem solving. We followed a strategy commonly used in industrial management based on the premise "imagining the future is shaping the future". The method "appreciative inquiry" was applied supported by a professional facilitator. Experience shows that this way of working sparks engagement and creativity and that progress and results can be reached within a short time. Focus was on the following topics of relevance to cereal production:

- Competition between food and bioenergy,
- Soil fertility management,
- Economical and legal conditions for variety improvement,
- Participation of stakeholders,
- Plant breeding strategies,
- Food and feed processing improvements,
- Sustainable land use.

The initial process was to visualise the most desirable future scenario for the seven essential topics in food and agriculture systems. This process was unhindered by no requirement for a market-driven goal. Each topic was discussed in relation to a broader socio-ecological system with a focus on the means to reach the desired and more sustainable outcomes. The next step at the workshop was to produce the discussion documents.

The final stage of the process is to connect the topics in a completed vision of cereal production within a future sustainable socio-ecological system. This is in progress by a group of key persons within the network, e.g. the working group leaders (in preparation for publication in a scientific journal).

For more information, www.cost860.dk
or

Chair of Network: Hanne Østergård, Risø National Laboratory for Sustainable Energy, Technical University of Denmark DTU, Roskilde, Denmark

[1] A European network for **Sus**tainable low-input cereal production: required **var**ietal characteristics and crop diversity

Cereals for food or for biofuels? - There are solutions

Will people in the future starve because they cannot afford cereals as a staple food? Prices of wheat and other cereals have rocketed during the last year. There is a world market shortage caused by a high demand for cereals for food, animal feed and biofuels.

But cereals are too valuable to be used as biofuels says a group of influential European scientists from 21 countries gathered in Denmark. Instead, they suggest more energy efficient cropping systems based on nutrient recycling. Perennial (not annual) energy crops will play an important local role while global energy supply will be based on permanent and CO_2-neutral sources e.g. solar radiaton, wind, water, and geothermal.

Reducing energy use

Currently, agricultural production is dependent on major energy inputs. Mineral fertilisers and pesticides account for a large amount of energy used in modern agriculture. Currently, for every kg of nitrogen produced one kg of fossil fuel is used accounting for up to 200 kg fossil fuel per ha. Much energy is also needed for phosphorus mining, processing, and transport. Soil management and transportation also consume fossil fuels.

Nutrients in food are exported from the farms to the consumers in the cities. Only a small part of these nutrients is returned to the agricultural land. However, nitrogen is fixed from the air by a large number of crops for free. Animal manure, human waste and plant residues contain the much needed nitrogen and phosphorus. They are valuable resources rather than waste products and must be reused by agriculture. Use of fossil fuels can be reduced by adjusting the crop and soil management and by the use of more energy efficient machinery.

Cropping systems for energy efficiency

Well designed cropping systems will reduce environmental impact at many stages. Reduced or no tillage diminishes the energy used in soil management. It will also result in a more permanent crop cover, increasing the organic matter in the top soil making the system more adaptable to dry areas. In addition, soil erosion and the pollution of ground and surface water through nutrient leakage is reduced. This requires crops competitive with weeds and resistant to other stresses.

Crop rotations with diverse crops strengthen these effects. Increased biodiversity will, in addition, help reducing weeds, insect pests, and diseases and, as a consequence, pesticide use. The intensive use of nitrogen fixing legumes such as peas, beans, and clover brings nitrogen from the atmosphere into the soil. The left over roots of the legumes improve soil structure.

Additional sources of nutrients are animal manure and compost. Human waste could be used in the system to fertilise energy plants without a risk for sanitary problems. The use of manure for biogas production can supply fuel for tractors and other vehicles without loosing nutrients such as nitrogen and phosphorous. To supply the organic matter needed, straw will have to be returned to the soil instead of being used for energy, however. In an optimised system animal and crop production must be closely linked to allow for this efficient recycling and to reduce long-distance transports of feed, food, and manure.

Future plant breeding will make it possible to design and produce crops of diverse characteristics. This will provide crops and varieties for specific use and can also enhance biodiversity as more diverse plant material will be grown. Crops suited to an energy efficient system will make good use of nutrients, water, and light. The food crops are characterised by high nutritional value, digestibility and processibility. Ideally, energy crops are perennial. This means they are planted

once and can be harvested one or several times per year over many years reducing energy use for planting and tillage. They will be grown in diverse mixtures as mixtures increase total productivity and stress resistance. Such plants will improve the economics of crop production and greatly reduce environmental problems.

To encourage the conversion towards such cropping systems there is a need to clearly define sustainability in terms of fossil fuel use. Energy efficiency can be determined either by looking at the amount of energy input relative to the amount of energy harvested. Analysing how much non-renewable energy is used will give insights into the long-term sustainability of a system. Basing farming support on such an analysis can be a new element to stimulate sustainable production.

Energy supply systems

Agricultural biofuel production will play a secondary role for world energy supply. It will mainly cover local energy needs for transportation and heating. Biogas, derived from animal manure, perennial energy crops and household waste, will be the main energy source here. Cereals will be used for biofuel only if quality is unacceptable for food or feed use and/or overproduction justifies this.

Globally, the main sustainable energy sources in the decades to come will be permanent and CO_2-neutral such as solar radiaton, wind, water, and geothermal power. Wind mills and solar panels will be landmarks like the castles of the past. Because nuclear fuel is also finite and nuclear waste management is an unsolved problem this form of energy is not sustainable. A major part of the additional energy can be gained from solar driven steam power plants in sun rich areas. If these are close to the sea, they can at the same time, through desalination, generate fresh water for irrigation.

Bright future with sufficient food and energy

We must bring together the many components that make up our living environment. Future agricultural systems will be based on reduced energy use and less competition between food and energy production. The main building blocks are increasing soil fertility through improved cropping methods, recycling of waste products, and greater efficiency in energy use.

Cereals will only play a minor role as energy crops. Crops for energy use should preferably be fast growing perennial (not annual) plants grown as mixtures. Future crop production, either for food or energy, will be designed for regional and local needs thus minimising transport.

The transition to this future will depend on individual action as most measures can be implemented independently. Every consumer and producer can support this change by shifting preferences to local food and energy sources but legislation encouraging sustainability will also have to help.

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This discussion document for non-specialist readers is one of a series produced by the European interdisciplinary COST860 SUSVAR Scientific Network during the SUSVAR Visions workshop[1]. This network aims at delivering required varietal characteristics and crop diversity for sustainable low-input cereal production.
For more information, www.cost860.dk

or

Chair of Network: Hanne Østergård, Risø-DTU, Roskilde, Denmark

[1] SUSVAR Visions workshop with 55 participants from 21 countries: Sustainable cereal production beyond 2020: Visions from the SUSVAR network, Karrebæksminde, Denmark, 14-16 April 2008.

Soil: muck or magic?

Our soils are sick and need to be fixed, now, before it is too late, according to a group of European scientists meeting in Denmark this week. Our lives depend on a dynamic, living community: the soil. However, the community is getting sick and dysfunctional, and needs a 'make-over'. Soil quality is essential for a robust agricultural system which will produce healthy, high yield, high quality crops to feed the world – the security of our food supply depends on it. Conventional farming practices have caused a great decline in soil health, and crop yield is now heavily dependent on large inputs of non-renewable artificial fertiliser. But farmers can produce all the high quality food we need while maintaining good, healthy and sustainable soil. Scientists now understand much more about how the dynamic balance of diverse organisms works in the soil as a community and how to maintain it. If we value this precious resource, our farming system will be able to go on feeding us for generations.

So what is a healthy soil: how do we get it and how do we keep it?

A healthy fertile soil is the foundation for good farming. In future, people will have a greater appreciation as to how we can use the soil better. This will allow us to grow healthy crops while not damaging our environment.

1) Use diverse crop rotations: *A sequence of different crop species rather than, for example, the continuous cereal production common today.*

- Better weed control
- Fertility building (e.g. grass-clover)
- Include leguminous (nitrogen-fixing) crops
- Pest and disease control

Example: Good: Peas - potato - wheat - grass/clover - oil seed rape – barley
Bad: wheat – wheat – wheat – wheat…

A healthy soil comprises a dynamic and diverse community of organisms in a matrix of organic and mineral particles, air and water. The organisms are everything from microscopic bacteria and fungi through to earth worms and 'bugs'. Such soil can support good yields of high quality crops with low external inputs such as artificial fertilisers and energy. It stores carbon from the atmosphere thereby helping to mitigate climate change. A well structured soil will limit erosion, help maintain water availability and reduce nutrient losses which contaminate drinking water supplies. Such soils are more tolerant to stresses such as drought, compaction by machinery or harmful organisms to plants.

2) Organic matter incorporation: *Adding animal manure and plant debris*

- Builds soil fertility
- Improves soil structure
- Incorporates more carbon
- Better water retention
- Buffers effects of soil salinity and alkalinity

So, how do we convert impoverished soils into healthy ones? By using improved crop management, particularly diverse crop rotations, incorporating organic matter and reducing soil tillage where appropriate (see details in boxes). The use of appropriate crop varieties and variety mixtures which are competitive with weeds and have improved nutrient, water use and photosynthetic efficiency, will complement all these practices. Healthy soils are by definition sustainable and therefore continued management using these principles will maintain them.

3) Minimise soil disturbance: *Only plough when necessary, avoiding heavy machinery use and tracking wet land*

- Reduces soil erosion
- Favours soil organism communities
- Improves soil structure
- Better water retention
- Reduce carbon loss

To control weeds use competitive varieties, mechanical weed management or targeted herbicides.

Traditional farming knowledge and practice gives us an excellent basis for developing and applying sound principles to achieve a sustainable agricultural system. For example, use intercropping of winter-sown wheat with a spring-sown grass-clover mix. Modern scientific tools and approaches (e.g. DNA fingerprinting of the soil microbial community) enable us to understand how these methods work. This allows us to improve and refine farming systems to meet the challenges of the future. Not least are the challenges of climate change, particularly new pests, pathogens, drought and more extreme weather events.

Sustainable agriculture is fundamentally-based on healthy soil. It is our most precious agricultural resource for the future. Our understanding of soils and their role in farming is improving through exchange of scientific knowledge and expertise across Europe. Translating this into practice across our farms is the exciting challenge which will achieve food security and protect the environment for future generations.

For more information on soil management try the following resources: www.soilassociation.org/; www.defra.gov.uk/Environment/land/soil/index.htm; www.defra.gov.uk/farm/organic/index.htm; school.discovery.com/schooladventures/soil/; www.ifoam.org/about_ifoam/principles/index.html; en.wikipedia.org/wiki/Soil_health

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Setting seed free
More voice for more choice in the seed sector

Diversity is demanded by consumers; they want enough and healthy food and new tastes. Diversity is also demanded by farmers; they search for new variety structures for higher and stable yield and they want to protect the environment. Finally, diversity is demanded by breeders; they need it to obtain new and sustainable varieties.

Nevertheless, diversity is becoming reduced through the organization of the seed sector and by law. Globalization of the seed sector has led to monopolization; big companies develop only few varieties able to cover the majority of fields in each climatic zone in Europe. A variety must be registered to be used but registration is expensive –some can't afford it– and registration imposes the variety to be stable and uniform –so heterogeneous varieties are excluded.

As exchanging seeds or cultivating populations is prohibited, diversity is not fitted by the rules. We need to revise the rules such that they are fitting for this purpose. The current regulations are like a poorly fitting shoe. Seed sector needs new shoes or no shoes at all. However, being without seed regulations has not prevented the monopolization of the seed market by agro-chemical companies so it may be comparable to walking barefoot.

Seed sector may, in a way, be compared with the software sector, where the monopolization is much more pronounced in the market for private computers. We don't want a similar situation in the seed sector, but there are lessons to be learned: the open source and free access system of software that have emerged shows diversity and creativity; these are examples to be followed. A parallel to the free access of software could be implemented in the seed sector, for the certification system and registration system of seed. As in the software system, the two parallel systems can be run side by side.

First step to diversity in seed: diversity among breeders

Medium and small companies, local cooperatives and farmers must have opportunity to be involved in breeding genetic resources adapted to sustainable production (including heterogeneous resources). This is one requirement to avoid monopolies and guaranty an increase of diversity.

The competences, skills and desires of each stakeholder need to be connected to share their objectives and build together breeding programmes such that a new variety encompasses the high nutritional level and taste that consumers are looking for, this together with agronomic traits which are necessary for farmers to produce high and stable yield with reduced pesticides (or without pesticides as in organic).

In order to walk together, all actors of the chain must wear comfortable shoes.

Why does the seed sector need rules?

Needs or rights of each actor in the chain are various in terms of protection –which leads to legislation–.

Consumers want to be sure they eat healthy and environment friendly products. Consumer protection legislation ensures it.

Farmers, who play the intermittent role between nature and consumers, want guaranties about the seeds they buy: they are adapted to their farm conditions (so they can target correct yields); they are free from diseases, pests and GMO (so losses are limited and products are healthy for consumers). In other terms, information (voluntary or obligatory) is crucial. Furthermore, farmers claim the right to save their own seed to use it again, as well as they claim the right to grow new and rare genetic material. And some of them claim the right to use and develop their own varieties.

Breeders, who invest in pluri-annual breeding programmes, need royalties to support this work and to continue to breed better varieties. They also want to be sure, before releasing a new variety, that it is suitable for a target agro-ecological zone. In case of varieties for niche market (as currently in organic farming), small climatic zones, local or specialized food product, costs for releasing on the seed market should be reduced so it is not a barrier.

A new challenge for the seed sector organization and the place of property rights

A challenge for the future of breeding is to fulfil the new needs in agriculture, by increasing the number of varieties having special characteristics. In order to answer the needs and rights of farmers and breeders, seed legislation has to evolve and find its balance between what should be obligatory and what should be voluntary.

We may imagine several systems ranged from two extreme systems.

One based on the current system, adapted and loosened for registration, but still based on royalties supporting the effort of breeding towards new issues, and on an evaluation process to assess the special characteristics of the varieties. To ensure quality of seeds sold to farmers, consumer protection legislation might be sufficient.

One based on the learning of free software. It could be done in a participatory way: the role of breeders would be also focused on the preservation of old varieties and landraces, to ensure the useful genetic diversity. Universities and public institutes would be main actors in pre-breeding, characterization and traceability processes of the closed system from farmer to consumer.

As information about seeds, varieties and genetic resources is clearly relevant for all stakeholders from breeder to consumer, the use of internet may be developed in a voluntary way, with scientific and protective objectives, to share information on rules and availability of seeds, results of research, breeding and evaluation (see box below).

Conclusion

The current seed regulation restricts the diversity of food products and has negative effects on the environment in terms of genetic and biological diversity. There is therefore a need to open up the development and use of a wider range of genetic material in agriculture.

We propose that in the future, it becomes possible to reintroduce landraces, and other plant genetic material, and to develop and market new varieties even if they do not fit the standards of the current seed regulation. But there is still a need of a regulation system for varieties that are sold on the open market with royalties for the breeder and seed companies. This system should be a voluntary guarantee system that does not exclude other varieties.

One challenge is to be able to feed people with respect to environment and climate change. Sustainable production of cereals in Europe plays an important role in it. This will be if the new

seed regulation permits diversity in breeding and access to seed market, therefore enhancing diversity in farmer fields and in consumer baskets.

Setting seed free on internet?
A vision to the future will be a ***European Free Informative Net*** *on organic cultivars and seeds.*
In this net will be interacted all the actors participating to seed production processes (farmers, breeders, seed companies and consumers, public organizations and private companies). It will present the results from on-farm workshops, breeding congresses, research and variety testing, as well as consumer views.
The database will provide all necessary information that includes the laws and rules for variety or genetic resources conservation and seed certification. Also, a helpful list with the certified seed lots and their characteristics unless variety description will be contained.
The aim of this interactive database will give scientific, protective (legality and authenticity) and creative opportunities for farmers, breeders and consumers.
Furthermore, this established open source will provide real-time access to seed suppliers and public organisations. In this case as an example, any farmer who wants to grow certified organic seed may submit a list of the cultivars sought along with the quantity needed and through this system might we have a full documentation of private companies, countries, cultivars and standards.

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Eat more to be healthy

Towards a divers food diet and an active participation of consumers in making decisions about their food production.

This vision presents a diversified agriculture that connects farmers and consumers and adapts to localities and cultures, and decreases environmental and health risks. In such an agricultural system an active participation of consumers in making decisions about their food production is essential. To have more to say in the way our food is produced and where it comes from, the consumer should know more about the ecological, cultural and economic aspects of agriculture. Therefore we need to develop educational programs on food starting from early ages at school. In addition different new forums should be available to involve society directly in an ongoing process exchanging information and evaluation on the ways of production and the nutritional value of our food products.

Nature is rich in edible species but we only use a few of them. Reducing the nutritional basis by ignoring such diversity causes us many problems such as malnutrition, overweight, diabetes, allergies, over-consumption of vitamins. Increasingly, food consumption is dominated by a few large producers and retailers. This results in a simplified food production orientated towards high profits with limited consumer choice.

The key step is to develop new food production systems that are more divers. Consuming more varied food is one of the easiest, cheapest and ecologically friendly ways to improve your health. Such new systems will take into account the different interests of all members in the food production chain.

Biodiversity can improve health and reduce risk

Food diversity depends on biodiversity of plants as well as on diversity of food processing in different cultures at a global, regional or local level. In our concept we focus on the biodiversity in the food production chain from farmers to consumers.
According to recent studies a healthy diet should be based on a high diversity of plants. Such a diet reduces the risks of human diseases and malnutrition. Eating more varied food is more fun. Exploring the cultural diversity of food is an adventure.

Another advantage of using a wide range of plants is that it is a good way to control pests, diseases and environmental changes on farms. However, there is a trend in current agriculture towards growing single crops. In the future, we need to grow a greater range of crops, using our knowledge of traditional farming systems. Within each crop we should grow a wide range of locally adapted types with different shapes, tastes and colours. How to get there?

How to breed for diversity

Nature itself creates biodiversity, but mankind has taken this further by careful selection over millenia. At the moment we are only using a small part of this diversity due to the intensification or industrialisation of agriculture in the last century. We will be using the original sources to develop new biodiversity. Farmers, breeders, processors and consumers are working side by side to achieve this. This participatory approach is an effective way to breed plants that are better adapted to local requirements and makes it affordable.

Connecting farmers and consumers

Nowadays in Europe farmers and consumers rarely meet. Consumers are more interested in their food, if they know where it comes from and can taste the difference. Reconnecting farmers and consumers can be done on three different levels.

The first and most appealing connection is the so-called local farmers market. In this case the consumer can meet the producer directly in farmers' markets, city farms or self-harvest plots. Alternatively farmers bring their products directly to the consumers through e.g. box scheme systems. In Italy we have even seen "farmers on tour" selling their wine to the public. Even going to on-line selling systems can contribute with information about the farm and its products.

The second level is a regional market system. The consumer and the farmer are connected by a third party. An example could be buying bread from an artisan bakery, which receives flour from identifiable regional producers.

The third level is a large-scale global market, but only for products that cannot be produced regionally such as coffee or tea. In these systems being able to trace the origin of the products is very important. Consumers will not be in direct contact with the producers but need to rely on organisations like Fair Trade, that make them feel in contact with communities of farmers. Consumers can influence food production by buying food products from existing sustainable food systems that emphasise diversity such as Organic Agriculture, Slow Food, etc.

Towards more knowledge

Agricultural food production has to provide food for everyone. The aim of our diversity-concept is to enable consumers to take part in and be responsible for their food production. To have more say in the way their food is produced and where it comes from the consumer should know more about the ecological, cultural and economic aspects of agriculture, see figure. Environment and agricultural practice influence food quality. Food ought to be free from harmful chemicals and more attention should be paid to the quality of food processing and nutritional values because food directly influences our health.

Towards future practice

To bring these ideas into practice we need to develop educational programs on our food is produced starting from early ages at school. Establishing discussion forums could be an instrument to involve society in an ongoing process in exchanging information and evaluation of the way of production and nutritional value of our food products. We can build on current examples of informing consumers such as the Nature & More system in the Netherlands and Organic Research website providing useful information on food production and quality. Another example is the Organic Monitor website providing information on products prices.

Moving towards an active participation of consumers in making decisions about their food production will provide a divers food diet. Food will end up to be a source of joy instead of risks.

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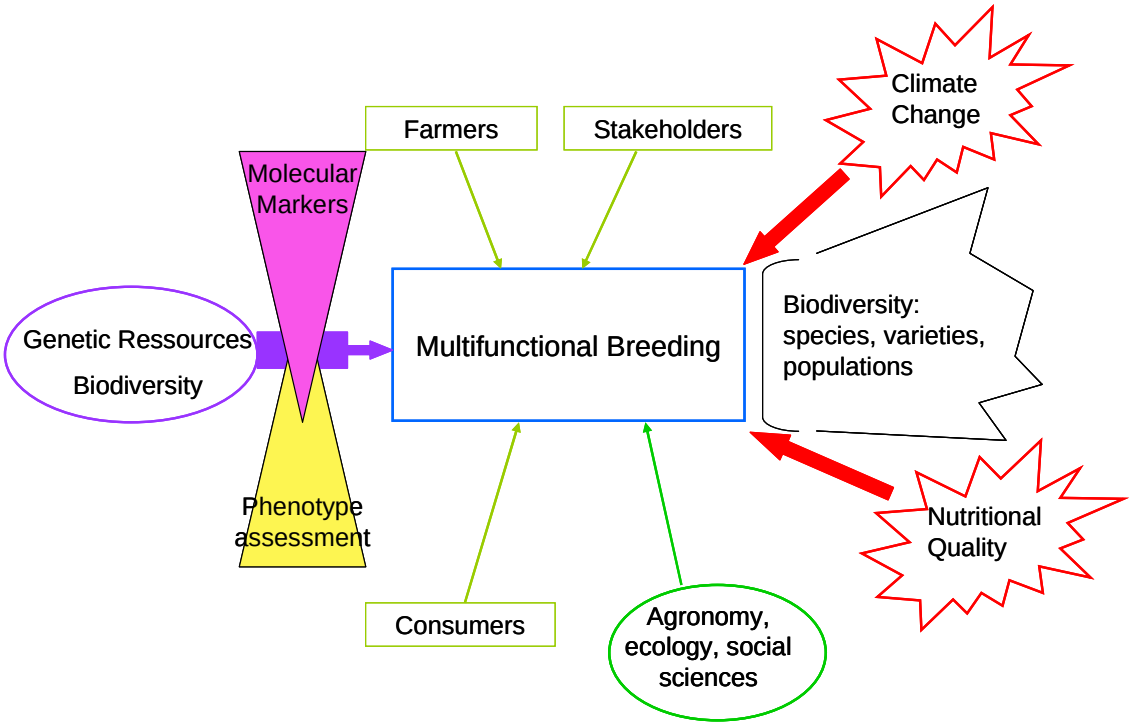
Future-proof food – plant breeding strategies to cope with climate change

Multifunctional breeding is seen by SUSVAR[1] scientists as the key strategy to develop new plants for 2020 and beyond that can face climate changes and deliver consumer demands for nutritional quality.



Mankind faces new challenges imposed by the growing impact of climatic changes. In the next 50 years the global temperature will increase at least 3 to 5 ºC, with negative consequences such as desertification, soil erosion and water scarcity with unpredictable weather year on year delivering floods, hurricanes, etc. These changes present a real threat to world food security alongside a negative impact on nutrition quality. There is then an urgent need for new plant varieties that can adapt to the challenge of our changing world.

New issues for plant breeding

Currently grown crops used in agriculture, such as cereals, have been improved to become well adapted to stable environmental conditions and their yield and quality depend on the great inputs in soil (mineral fertilizers, water, pesticides). Since the domestication of the crop species, farmers have been using varieties with a broad genetic basis well adapted to local climatic conditions. Altough in some parts of the world, for example in Anatoly, Turkey, such varieties are still in use by farmers to get some production even in unfavourable years, it is no longer the case in most regions where industrialized agriculture has been adopted. The diversity of species, varieties and populations offers homeostasis (box 1) for many changes to biotic and abiotic stresses.

Box 1. Homeostasis is the capability of crop in farmer plot to buffering the environmental constraints and ensure high yield stability.

[1]A European network for **Sus**tainable low-input cereal production: required **var**ietal characteristics and crop diversity.

Most of the traditional and old varieties are not cultivated anymore and knowledge about their specific characters has been lost or is not available. Although in the marginal ecosystems or "living historical museums" such as Vavilov's domestication Centre, for example Fertile Crescents, neglected species (crop species that are no more in used), wild species or crop wild relatives still grown and keep this diversity. Germplasm banks, such as Svalbard Vault or Norway's Noah's Arc, are also important reservoirs for preservation of the old varieties to safeguard the needed genetic diversity to face the new challenges of agriculture. In addition, the Genebanks along with international political authorities (FAO) encourage the *in situ* conservation of these heritage treasures (box 2) and increase their irreplaceable use in plant breeding programs.

Box 2. The heritage includes the **genetic resources** of all living organisms and their components. It includes also native species, wild introduced species, wild crop relatives, old varieties, landraces and also crops varieties, developed or selected by man.

These resources may harbour many neglected and unknown variants usefull for building the new armours to face climatic changes and "horn of plenty" to exploit new nutritional qualities.

Multifunctional breeding based on intensive use of genetic diversity

Because of the diversified uses and needs, and to face changing and heterogeneous environments, it is no longer possible to develop a single breeding strategy for varieties aimed at growing all over the world. Different and multifunctional strategies are needed to develop different varieties adapted to the local conditions (climate, soil, agricultural practices, market and society). Multifunctional breeding include breeding for multiple purposes, using different strategies and developing different kinds of varieties. Yet the incorporation of genetic resources will be a crucial common feature in these strategies. The huge diversity stored in genebanks can be used directly by distributing landraces of a crop species or of neglected species to groups of farmers but mostly it should be screened before used in breeding programs. Then the different interesting features can be captured through crosses among genetic resources and more recent cultivars and followed by selection of progenies for the development of varieties such as "pure lines" or hybrids, which are homogeneous varieties or populations, which are heterogeneous varieties.

But genetic diversity should not be only seen as a material for breeding but also as a strategy for cropping to buffer environmental variations over time and space.

First, increasing the number of species grown in each farm (crop rotations, intercropping) will decrease disease pressures, and respond to consumer demands for diverse food.

Second, it is crucial to develop more diverse varieties relying on a wide gene pool, so that they do not carry the same genes over large areas and so that they can be adapted to the local conditions. The case where a single or a few related varieties are spreading all over a country or a continent might be much more dramatic in the future. Variability over space can be considered from the scale of the landscape (different fields with different varieties) to the scale of the field (mixture of varieties within a field).

Finally, breeding of heterogeneous varieties has a great potential to respond to the variable and changing environments and consumers' demands. Because they can continuously adapt to the changing biotic pressures (composition of pest and diseases populations) and changing climate by recombining genes and traits, catching new mutations and through exchanges of seeds between farmers, breeders and actors involved in the genetic resources conservation, such populations can constitute a more flexible breeding method. By combining human selection practices to the natural selection process, this would allow to deal with traits, such as nutritional quality characters, that are not connected to environmental adaptation. These populations-varieties will also be able to finely fit

to each different region or specific environment, allowing for multiplicity of genotypes and diversity maintenance.

Because the farmers are highly concerned by climate change and end-users and consumers best know what kind of characters they need and wish in the products, they should be involved in the breeding process and/or in the conservation of genetic resources.

Which characters in the genetic resources might be most usefull

To increase cultivated diversity and improve the use of plant genetic resources in breeding there is a strong need to develop our knowledge regarding different agronomic and quality traits. The evaluation of genetic resources requires rapid methods to screen large number of samples for micronutrients (Zn, Se, Fe and Cu) vitamins, antioxidants substances, inulin and responses to biotic and abiotic environments. New cultivars are needed to recombine high level of durable resistance to the main important diseases (air and soil born), high stand establishment and high efficiency for nutrient and water uptake and utilization.

Tools helping to use the genetic resources

Recent advances in molecular technologies (Box 3) together with knowledge on the genes functions and expression will provide useful tools to help for breeding of genotypes with superior agronomical performance in relation to climatic changes and nutrition quality.

Box 3. The **molecular markers** are different DNA sequences known to be located in specific parts of the genome. Molecular markers covering the whole genome of cereals can be detected by modern technologies.

If molecular markers are linked to variants of genes of interest, the detection of presence/absence of the marker will give indications on the presence/absence of the gene variant which is responsible for the particular trait. Thus, molecular markers allow for the discovery of new useful variants in landraces or in wild relatives of cultivated crops. The so-called M*arker Assisted Selection* (MAS) method has been developed on these basis. For plant breeders, the most useful application of MAS in giving value to genetic resources will be tracing and combining:

- traits that are difficult to evaluate such as tolerance to environmental stresses (cold, drought, etc);
- traits that are laborious to phenotype like the amount of healthy specific compound;
- disease resistance without the infection test analysis.

By giving the possibility to select plants on very early stage of development, molecular markers will allow to increase the efficiency of selection and to accelerate new varieties development with a complex of adaptive traits.

Handling of large amount of molecular and phenotypic data will not be successful without appropriate statistical assistance. Statistical methods and bioinformatics are powerfully tools for screening and taking decisions about the genetic resources that are the most valuable/diverse, that should be protected, collected and kept in genebanks and/or used in breeding programs. In this regard, the integration of diversity data characterizing within and among genetic resources based on the use of molecular markers and phenotypic patterns will be a recurrent requirement. As more information at different levels (genome, gene expression, proteins, metabolic substances, phenotype) will be available, more integrative methods should be developed to analyse the influence of different environmental components on the genetic resources.

Breeding as a contribution to a holistic approach

In our new world of environmental challenge to agriculture, biodiversity and multifunctional approaches will be the core of agricultural research proposal but it is critical that plant breeding/genetics should not be considered as a magical solution for all problems. They should instead be used as part of an integrated approach that includes agronomy, ecology and social sciences.

A big question is who will be in charge of genetic resource conservation and who will pay? In addition to governments, the contribution of commercial companies must be ensured so that genetic resources centres have the means to conserve, manage, screen and make information widely available.

Underpinning change in the field must be change in seed regulation. European agricultural policy too should be modified to favour farming systems based on crop diversity, even in small farms where it might be seen to be economically difficult. And one final, novel thought; crop management should also be part of EU agricultural regulation.

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For more information, www.cost860.dk

or

Chair of Network: Hanne Østergård, Risø-DTU, Roskilde, Denmark

[2] SUSVAR Visions workshop with 55 participants from 21 countries: Sustainable cereal production beyond 2020: Visions from the SUSVAR network, Karrebæksminde, Denmark, 14-16 April 2008.

Wholemeal – Good Feel

Cereal grains for healthy food and feed

Imagine a healthy future, sustained by quality cereals that provide nutritious and tasty food. This is the vision of a European-wide group of scientists who recently met in Denmark. "The path to better health starts from higher quality and greater diversity in our food", said the group. The vision embraces friendly farming and cereal processing to benefit all of society and their farm animals.

Every day, we are alarmed to hear that our health is under threat from what we eat. Doctors warn against certain foods. They tell us to lose weight to support our hearts. Obesity and food allergies are becoming epidemics.

The vision of cereal-based food and feed of the future is that grains and their products will be of the highest quality. Cereal foods inherently have high nutritional value. A mixture of different grains packed with essential nutrients – in the correct balance – can provide the diversity in range and taste of our dietary demands. This makes for healthier people and happier animals.

Quality will no longer be limited to the well-preached requirements for starch, protein and fat. Rather, it is the complementary nutritional requirements of people and animals that will be important, as well as taste and authenticity.

The benefits of whole grain products are recognised. They contain most of the components necessary for human and animal well-being. They are an ideal source of energy. Whole grain products help our digestive system to reduce the risk of types of cancer and related problems.

Our health can be improved without the need for additives or supplements. This includes foods for individuals sensitive to specific ingredients or those with special dietary requirements. Fibre content, in barley and oats, can reduce cholesterol levels in humans. There are also particular cereals that are more efficiently digested by animals: this enhances their well being and improves the flavour of the meat they provide.

Embracing wider crop diversity in the breeding of new plant is crucial to developing wholesome grains containing higher levels of vitamins, fibres, proteins and minerals. Plant breeders can deliver a broad spectrum of crop varieties to provide society with an ideal balance of nutritional qualities. Farmers can choose which varieties to grow according to the soils and weather on their farm. Matching the variety to the environment guarantees an efficient uptake of the nutrients and grain supply of the desired quality.

Linking food production with more environmenatlly considerate ways of farming will not compromise the supply and quality of the farmers' harvest. On the contrary, farming that is better balance with the environment provides for a more sustainable agriculture. Adopting the best of new technology on farm and during processing optimises energy inputs and reduces waste.

We know that the weather has a strong influence on the quality of our crop harvest. Seasonal effects are often unpredictable. Recent understanding of the ways in which farmers can meet the challenges imposed by the weather and soil types on their farms allow them to take better control over the raw ingredients they provide for the millers, bakers, maltsters and the myriad of end users who process our food. In turn, farmers are rewarded for the grains they produce in meeting the quality spec we demand.

The processing of cereals – as milled or whole grains – has vastly improved. This satisfies our high level of quality assurance and increased efficiency across the whole food chain. Today, more than ever before, grains can be processed in such a way that our bread, breakfast cereals, beverages and healthy snacks maintain the maximum amount of good nutrients within them, with often all parts of the grain being used. Likewise, healthier animals enhance the quality and nutritional value of meat, egg and milk products.

Better processing, often through a local supply and demand, encompasses less artificial additives or extra refinement during the mixing, sieving, baking and packing of our favourite foods. Traditional methods add to the diversity in our foods – and these now sit comfortably beside the new technology that improves the efficiency in energy and water use.

Society demands and appreciates better nutritional value its foods and animal feed. "As consumers, we can choose products according to the good influences they have on our health", say the group. Embracing the advancements in crop and variety choice, grain quality and processing technology takes us along way down the path to wholesome food – and good feel.

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'Ecological dictator' needed for security of land use

Currently, fertile agricultural soils are being consumed by an increasing rash of concrete. This cannot continue as such soils are finite and limited, say scientists from the European SUSVAR network. The conflict of interest between sustainable land management, farming and society will increase in future unless immediate action is taken. They stress that there should be a focus on multifunctional and integrated approaches, including education at all levels of society. The benefits are many, for everyone, and the sustainability that emerges is essential.

There is a major issue with the loss of agricultural land, other natural resources and energy. The main reasons are a combination of increasing population, urban growth on good land and the abandonment of poor agricultural land.

Fifty scientists from 21 countries recently attended a workshop to discuss their vision of sustainable land use in 2020. This interdisciplinary group of European scientists from the COST action SUSVAR[1] gathered at Karrebæksminde in Denmark to conclude on their 4 years project and to formulate recommendations.

The main issue recognised during the workshop relates to erosion of the links between land management, farming and society. In order for land management to be sustainable this primary issue needs to be addressed rapidly. Multifunctionality and integration of whole systems is the key. This integrates food, energy production and us as well as ecosystem sustainability with social aspects in systems appropriate to localities. At present this approach hardly exists, but there is a desire that by 2020 it will be common.
Education at all stages of life is at the core of the strategy put forward to achieve this aim. It represents the main tool by which people can be made aware of the advantages of responsibly using natural resources, landscapes and the environment as well as their many interactions. All of society should be involved in this movement to spread understanding of the importance of the issues involved. Information can be delivered using a variety of methods, tailored to achieve maximum impact across all age and social classes. Particular attention will need to be made to the continuing development of the managers of land including the knowledge, skills and the introduction of improved practices, based on sound scientific principles. The underlying science will need to be focused much more on a holistic systems approach than is currently the case.

A major key for success in the use of this research depends on a new balance between agroecological and biotechnological engineering. The solution to sustainable land use lies in a global participatory approach involving everybody. For instance, from both the economic and environmental points-of-view, it is more efficient, effective and cheaper to supply water from a watershed converted to organic farming than to clean water in water purification plants as shown by the experiences in Munich, several Swiss cantons and New York. Frequently, later sowing of autumn cereals to control aphids and some diseases is likely to be more efficient than either pesticide use or sophisticated biotechnological breeding approaches. Why complicate the issue when simple methods, such as these, are all that is needed to reduce inputs and energy costs? Chemical and biotechnology should be regarded as tools and not as the heart of the system. Here, the use of marker assisted breeding to accelerate the introduction of resistance to the powdery mildew disease in barley has already proven its usefulness.

[1] COST action 860 SUSVAR (Sustainable low-input cereal production: required varietal characteristics and crop diversity)

New criteria are needed to allow us to move away from the present focus on maximum yield to an optimum which takes into consideration the economic, ecological and societal aspects of final yield. One example is agroforestry which is the integration of trees into farming systems to produce a wide array of positive interactions among trees, crops, animals and the farmer. For example, trees can provide shelter and browse (forage) for animals, habitat for beneficial insects and nutrient supplement for plants through fallen leaves in the autumn. On the other hand, the presence of crops among the trees can reduce the spread of pests and diseases among the trees and their competition for resources, such as light, nutrients and water. These are 'free' ecological benefits that can lead to overall higher productivity from one unit of land, relative to crops, trees or animals produced separately. In addition, the increased range of products (wood products, energy, biodiversity, and aesthetics) from that unit of land can extend income and employment while limiting, or eliminating, the use of synthetic inputs, particularly in organic agroforestry.

Such complex and fully integrated systems can provide the ingredients for healthy and comprehensive food systems and cultures, including production and distribution, with a high level of economic, social and environmental security. In addition, these systems provide benefits in many other directions. On the biological side, this includes a wide range of ecosystem services (e.g. carbon capture, clean water, healthy biodiversity, insect pollination, decreased pollution), all of which at present are highly undervalued by much of society. The diversity and complexity of these systems also lead to attractive and stimulating landscapes.
For society, there is a host of other potential benefits including wider and more secure employment, the potential for care of disadvantaged and elderly people, and the delivery of cheap, local energy sources.

So why do we need an ecological dictator? We need one to force a rapid paradigm shift from consumption of resources to one which maintains or even generates them, before it's too late.

Agroforestry links: http://www.montpellier.inra.fr; http://www.macaulay.ac.uk,

http://www.ukagriculture.com.

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